Force Homework (due Wed, 2/27/19)
Name:

Newton's Laws		
1	Inertia	$\Sigma\vec{F} = 0$
2	F = ma	$\Sigma\vec{F} = m\vec{a}$
3	Karma	$\vec{F}_{12} = -\vec{F}_{21}$

Forces		
Gravity	$m \cdot g$	$g = 10\ m/s^2$
Normal Force	F_N	Comes from Surfaces
Tension	T	Always pulls
Static Friction	$f_s = \mu_s \cdot F_N$	Not Moving
Kinetic Friction	$f_k = \mu_k \cdot F_N$	Moving

1. **Solve (Don't forget units):**
   1.1. **If m = 7 kg, and a = 3 m/s^2, find F.**

F = $m \cdot a = (7\ kg) \cdot (3\ m/s^2) = 21\ N$

   1.2. **If F = 48 N, and a = 12 m/s^2, find m.**

m = F/a = (48N)/(12 m/s^2) = 4kg

   1.3. **If F = 40 N, and m = 5 kg, find a.**

a = F/m = (40N)/(5kg) = 8 m/s^2

2. **Is it possible to have motion in the absence of a force? Explain**

Yes, Newton's first law says that in the absence of a net (total) force, an object will either stay at rest OR continue moving with a constant velocity forever.

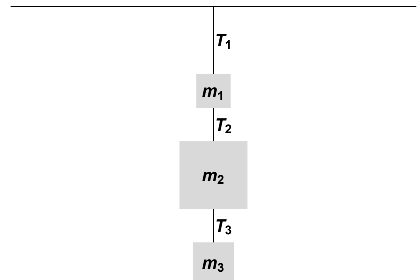
3. **A baseball (mass m) is thrown upward with some initial speed. What is the force on the ball when a) it reaches half its maximum height and b) when it reaches its maximum height?**

Ignoring air reistance and wind, the ONLY force acting on the ball while it is in the air is GRAVITY. You were not asked about the force of the hand throwing the ball initially. So:
a) Gravity
b) Gravity

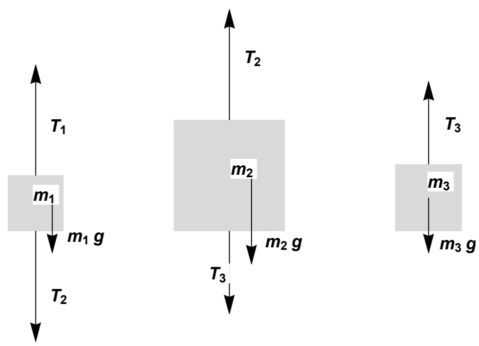
4. **If it's true that when you push on a small book, it pushes back at you with an equal and opposite force (Newton 3), why does it move?**

Newton's 3rd Law says that whenever there is a force, there is an equal and opposite for to it, so forces ALWAYS come in pairs. For this problem, the force pair we are focusing on are YOU pushing the BOOK, and the BOOK pushing on YOU. They are equal and opposite, but when finding out how an object moves, you need to use Newton's 2nd Law, which tells you to add up ALL of the forces on an object, and that sum will be equal to the object's mass times its acceleration. In this case, if the force you exert on the book is greater than the force of friction between the book and the surface it's on, then the book will move.

5. **A block of mass m_1 = 2 kg hangs by a string from the ceiling. Another block of mass m_2 = 5 kg hangs from the bottom of m_1, and a third block of mass m_3 = 3 kg hangs from the bottom of m_2. Find the tension in each string: T_1, T_2, and T_3. Do this by drawing Free Body Diagrams (FBD) for EACH mass and then solving Newton's first law for each block.**



FBD:



Newton's 2nd Law: ΣF = ma. Since the blocks are just hanging there, a = 0.

m_1: y-direction
ΣF = 0
$T_1 - T_2 - m_1 g = 0$

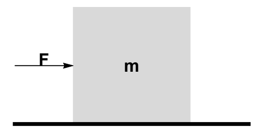
m_2: y-direction
ΣF = 0
$T_2 - T_3 - m_2 g = 0$

m_3: y-direction
ΣF = 0
$T_3 - m_3 g = 0$
$T_3 = m_3 g$ = 30 N

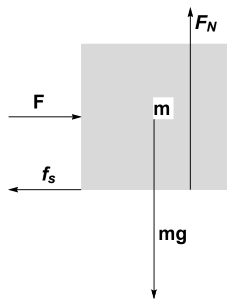
$T_2 - m_3 g - m_2 g = 0$
$T_2 = m_3 g + m_2 g$ = 30 N + 50 N = 80 N

$T_1 - T_2 - m_1 g = 0$
$T_1 = T_2 + m_1 g$ = 80 N + 20 N = 100 N

6. **A block of mass m = 4 kg sits on a rough (μ_s = .7) horizontal surface. Draw the FBD of the block. How big does a force F have to be so that it will just start moving?**



FBD: Since the force F is pushing the block to the right, the friction force f_s is resisting F and points to the left.



Newton's 2nd Law: ΣF = ma. Since the block is not moving, a = 0 in both directions.

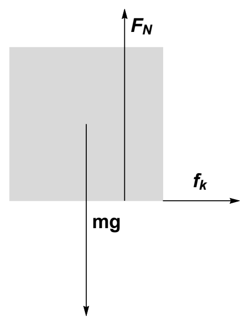
m: x-direction	m: y-direction
ΣF = 0	ΣF = 0
$F - f_s = 0$	$F_N - mg = 0$
	$F_N = mg = 40$ N

$F - \mu_s F_N = 0$

$F = \mu_s F_N = (.7)\cdot(40 \text{ N}) = 28$ N

7. **A block (m = 9 kg) slides on a rough surface (μ_k = .4) with an initial velocity of 5 m/s to the left. Draw the FBD of the block, find the friction force, the acceleration of the block, and the time it takes to come to a stop.**

FBD: Since the block is moving to the left, the friction force f_k resists this motion and is to the right.



Since the block is moving sideways, acceleration in the y-direction is zero.

m: x-direction	**m: y-direction**
ΣF = ma	**ΣF = 0**
f_k = ma	**F_N - mg = 0**
	F_N = mg = 90 N

$f_k = \mu_k F_N$ = ma

f_k = (.4)·(90) = (9)a

f_k = 36 N **= 9a**

a = 4 m/s^2

Kinematics 2: Since the block comes to a stop, we set the final velocity v = 0.

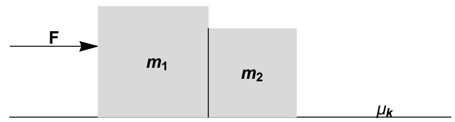
v = v_0 + aΔt

0 = -5 + 4Δt

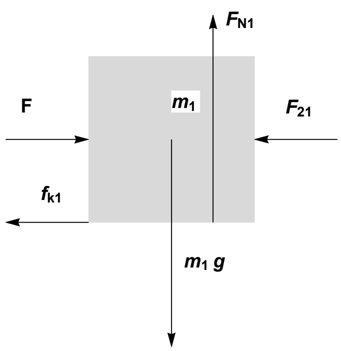
5 = 4Δt

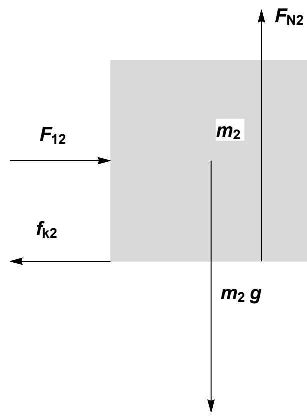
$\frac{5}{4}$ **= Δ**t = 1.25 s

8. **2 blocks pushed are pushed to the right on a rough surface (μ_k = .3) with a force of F = 12 N. m_1 = 8 kg, m_2 = 5 kg. Draw the FBD for each mass, find the forces between the blocks, F_{12} and F_{21}, and the acceleration of the system.**



FBD: Since the force is pushing it to the right, the friction forces (f_{k1} and f_{k2}) are to the left. F_{12} and F_{21} are equal and opposite.





Since the blocks are moving sideways, acceleration in the y-direction is zero.

m_1: x-direction	**y-direction**	**m_2: x-direction**	**y-direction**
$\Sigma F = m_1 a$	$\Sigma F = 0$	$\Sigma F = m_2 a$	$\Sigma F = 0$
$F - f_{k1} - F_{21} = m_1 a$	$F_{N1} - m_1 g = 0$	$F_{12} - f_{k2} = m_2 a$	$F_{N2} - m_2 g = 0$
	$F_{N1} = m_1 g = 80$ N		$F_{N2} = m_2 g = 50$ N
$F - \mu_k F_{N1} - F_{21} = m_1 a$		$F_{12} - \mu_k F_{N2} = m_2 a$	
		$F_{12} = \mu_k F_{N2} + m_2 a$	

$F_{21} = F_{12}$

$F - \mu_k F_{N1} - (\mu_k F_{N2} + m_2 a) = m_1 a$

$F - \mu_k F_{N1} - \mu_k F_{N2} - m_2 a = m_1 a$

$F - \mu_k F_{N1} - \mu_k F_{N2} = m_1 a + m_2 a = (m_1 + m_2) a$

$12 - .3(80) - .3(50) = (8+5)a$

$12 - 24 - 15 = 13a$

$-27 = 13a$

$\frac{-27}{13} = a = -2.08\ m/s^2$

$F_{12} = \mu_k F_{N2} + m_2 a$

$F_{12} = .3(50) + 5(-2.08)$

$F_{12} = 15 - 10.4 = 4.2\ \text{N} = F_{21}$